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On Innovation: How do Revenue Variations Affect Research Expenditures Within U.S. Research Universities?

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***Abstract*-In this study we examine the revenue expenditure relationships within public and private research and doctoral institutions. Results suggest tight relationships between some revenue and expenditure categories. Instructional expenditures are significantly influenced by revenues from tuition and fees, governmental appropriations (for public institutions), and grants and contracts. These results are significant both statistically and substantively. Research expenditures are affected first and foremost by government grants and contracts, and this is especially true at private institutions. Revenues from tuition, appropriation, and private gifts have a rather moderate effect on research expenditure. These results are consistent with the resource dependency interpretation of resource allocation patterns. Although the relationships between some revenue and expenditure categories are tight, the categories themselves are very broad and defined by historical convention rather than current practices and may need refinement.**

Introduction

Innovation is a major source of national income growth and thus of enhanced international competitiveness. Economists have estimated that as much as half of the overall increase in gross domestic product in the United States since 1945 has resulted from technological innovations (Steil, Victor, & Nelson, 2002). Universities are major contributors to a nation's innovative outcomes, largely through their academic departments and research centers and institutes.

Universities and their internal units derive their revenues from many sources, including tuition and fees, state appropriations, state and federal grants and contracts, and endowment earnings. Expenditure categories include instruction, research, public service, scholarships and fellowships, student services, academic and institutional support, and operation and maintenance of the physical plant. These categories are considered to be "functional" expenditure categories. Observing the relationships among variations in university revenues and variations in expenditure patterns is important because revenue providers, e.g., the federal and state governments can thereby structure their subsidies, e.g., block grants, research grants, student aid subsidies, to promote particular policy outcomes. Similarly, universities themselves can adjust their internal allocation patterns in ways that will provide internal actors with incentives to promote particular outcomes. For example, some functional expenditure categories connect intuitively to innovation. Allocations to research (and ultimately to publication of research papers, completion of patent applications, and the licensing of intellectual property) and to scholarships and fellowships (especially for graduate students) may lead to scientific discoveries, establishment of economic relationships with firms, and development of new technologies. Allocations to instruction of course, as well as to research, translate into production of degrees in fields such as science, technology, engineering and mathematics. Other functional expenditure categories make tangible but less direct contributions to innovation. Academic support for libraries and much of the university's technology, and institutional support for administrative offices such as the VP for Research and Dean of the Graduate School, contribute indirectly but not insubstantially to innovation. Consequently, identifying what factors predict university expenditures in areas such as research becomes an important policy matter. One means by which to conduct such an inquiry is to investigate relationships among revenue sources and functional expenditures. As the saying goes, "Follow the money."

Several investigators have pursued this line of inquiry and produced useful results. Perhaps the earliest such study was conducted by Hasbrouck (1997), who observed

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that state appropriations were more likely to be used to support instruction than were state categorical grants, which often were used for research. Hasbrouck's findings demonstrated that relationships between revenue sources and expenditures did exist and that studies focusing on these relationships could illuminate important facets of university operations. Zhang (forthcoming) employed a similar approach to examine whether specific revenue sources contributed more than others to increasing college graduation rates.

In regard to innovation, such work demonstrates that how universities receive and spend their money does matter. Without a grasp of these relationships, it is difficult to know how university behaviors that ultimately will impact innovation best can be supported. Understanding these relationships also may suggest specific external policy initiatives, such as how best to target or broaden federal research funding and how best to increase the scientific labors force that can be expected to foster innovation.

This paper expands understanding of higher education's contribution to innovation in several important ways. First, whereas Hasbrouck (1997) utilized data from decades ago, we extended the analysis to most recent years so that the changes in revenue/expenditure relationships could be updated and observed over a longer period of time. Second, we employed more dynamic models (e.g., panel data analysis) to examine not only how institutions responded to changes in revenues, but also how responses within institutions changed over time. The latter has more straightforward and important policy implications. Third, we focused on public and private research and doctoral universities rather than all four year colleges and universities as did Hasbrouck because we assume that research and doctoral universities play a central role in innovation. While our ultimate goal is to identify and quantify variations among income sources and expenditure patterns that relate to innovation-related outcomes, in this paper we test the full gamut of revenue and expenditure relationships as an initial step in identifying and quantifying the most basic revenue-expenditure relationships.

Literature Review

Nelson (1996) offers a most insightful explanation about how economic development occurs. In his analysis, technical advance – that is, innovation –is the "key driving force behind economic growth" (p. 1). This indeed seems to have been the case in recent U.S. history, at least in the view of several analysts. Gordon (2002) credited both the "golden age" boom of productivity, from 1950-1972, and the recent period of growth from 1995-2000 to technological advances. In Gordon's analysis the earlier period reflected the diffusion and application of the electric motor, internal combustion engine, and other inventions from the late 19th century. The 1995-2000 boom in productivity resulted from advances in computer and information technology. These dynamic periods strongly suggest that cycles of economic growth depend upon technological innovations. Conversely, periods of low growth coincide with limited technological progress; Gordon attributes the stagnant period 1972-1995 to the "inevitable depletion of the fruits of great inventions" (p. 61). In order to understand cycles of economic growth, then, it becomes necessary to understand the conditions under which innovation occurs.

Feldman (2003) argued that a single "anchor tenant" may attract innovative firms and skilled labor to a region. While an anchor tenant may be necessary to an innovative system, however, a single firm is not sufficient to sustain technical advance over time. As illustrated by recent economic history, a sustainably innovative climate relies upon a convergence of many factors. Both Japanese and U.S. firms developed many new innovative technologies in the 1990s. Japan's economy languished and the U.S. economy flourished, however, because ready supplies of liquid capital and a favorable regulatory environment made the United States far better positioned to translate innovations into economic growth than was Japan (Steil, Victor, & Nelson, 2002). These historical examples suggest that a sustainable climate that supports innovation results from a complex interaction of firms, structures, and processes, not simply from one or a few innovative firms (Bercovitz & Feldman, 2005; Nelson, 1996, 1995).

Nelson (1995) terms this convergence of many factors the "co evolution" of firms, research, and policy. The importance of co evolution becomes clear when we consider the processes by which innovations diffuse and are applied across an economy. New technologies represent sizable investments. Firms take substantial risks when they invest heavily in research and development and assume additional risks when they are the first to implement new technologies. Technological advance therefore thrives when a series of actors share the burdens of research and development. Innovation, in other words, demands collaboration among different actors, including the state, if they are to be developed, produced, and implemented at competitive prices (Jessop, 1993). Constellations of innovative firms rely upon a wide range of external institutions, including favorable legal and regulatory environments, to support their work (Nelson, 1995).

State support often arrives through favorable regulation, monetary policies, and intellectual property laws. Yet the high cost of developing new technologies suggests another vital role that states can play in fostering innovation: research funding (Steil, Victor, & Nelson, 2002). U.S. policymakers themselves implicitly recognized this role for research funding in the 1990s. In the years after the end of the Cold War, political rationales for federal research funding shifted toward supporting projects aimed at boosting "global competitiveness" rather than promoting the national defense or health care initiatives (Slaughter & Rhoades, 1996).

Universities were ideally positioned to participate in the policy climate that emphasized global competitiveness as a rational for federal research funding. Having long institutionalized engineering and other technology-based programs as formal academic departments, American universities offered research capacity with an inherently practical

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bent. Further, universities had long competed for federal research funds, and therefore responded quickly to changing rationales for research funding (Nelson, 1996). Gordon (2002) lists the capacities of American research universities to capitalize on public funding as an important contributor to the sharp rise in worker productivity from 1995-2000.

Research conducted on university campuses contributes to innovation and economic growth in several different ways. University-based research may be immediately commercialized, as is the case when discoveries yield patents, licenses, and spin-off companies (Bercovitz & Feldman, 2005). Academic research also offers a range of "indirect" benefits, as when discoveries in mathematics or physics are applied in fields such as chemistry and engineering (Nelson, 1996). University-based research also creates "knowledge spillovers," through which firms located in a particular area benefit from the synergies between their own work and the projects undertaken by a university (Feldman, 2003; Feldman & Kelly, 2006; Owen-Smith & Powell, 2004). We suggest total university spending on research activities may be the most appropriate measure available for the research activity of an individual university.

However, not all universities are equally well-positioned to conduct research. Owen-Smith and Powell's (2004) study of the Boston biotechnology sector suggests that organizational structure and behavior substantially affects whether an organization is well positioned to participate as an active node in its market network. In other words, intra-organizational structures and policies can affect whether an organization participates in the arenas in which innovation occurs. A study by Bercovitz, Feldman, Feller, and Burton (2001) emphasizes contributions that research universities make to economic development via technology transfer. Their results confirm the importance of organizational structures and processes to understanding the contributions that an organization makes to innovation. In short a study of university contributions to innovation must account for the intra-organizational processes that predict the desired outcome.

One particularly useful technique by which to conduct such an analysis is the study of revenue sources as predictors of organizational behavior and effectiveness. Such studies effectively emphasize intra-organizational resource allocation by asking whether the sources from which individual universities draw their revenues predict functional expenditure categories. Analyses of this type have consistently yielded valuable insights into the behavior of universities. Hasbrouck's (1997) study uses cross-sectional regression techniques to analyze financial data from 175 public universities. Her study demonstrates a consistently positive relationship between state appropriations and expenses for instruction. Ryan's (2004) more recent study also demonstrates that institutional expenditure patterns proved significant predictors of graduation rates. In Ryan's account, universities that devote higher proportions of their resources to instructional expenditures generally evidence higher graduation rates than do their peers. These studies suggest that the analysis of intra-organizational resource allocation provides a valid window through which to study universities' performance and behavior.

While instructive, the two studies cited above face a substantial limitation. Both Hasbrouck (1997) and Ryan (2004) conducted only cross-sectional analyses (i.e., they examined data at one or more fixed points in time). Do analyses conducted over time yield different estimates of effects than do cross-sectional studies? Indeed, Zhang' study (forthcoming) draws just such a conclusion from analyzing the effects of institutional revenue sources on graduation rates. Zhang's paper first presents a cross-sectional analysis, which suggests that a variety of institutional characteristics, such as the mean SAT score of entering students and the institution's tuition price, affect an institution's six-year graduation rate. However, Zhang also presents a panel analysis that controls for unobserved institutional effects and yields different estimators than the cross-sectional account. Zhang's panel analysis suggests that institutional influences upon graduation rate may have been overstated in the cross-sectional model. Zhang's panel model instead shows state appropriations as a strong predictor of graduation rates. Zhang's results suggest that there is great value in analyzing data using panel techniques that can account for the unobserved effects of specific, internal units and/or time periods. Further evidencing this claim, Ehrenberg and Zhang (2005) used fixed effects panel analysis to demonstrate the consequences of another organizational characteristic, the relative incidence of tenure-track faculty members on graduation rates.

There is also an important conceptual reason for employing a dynamic technique such as panel analysis. Nelson (1996) posits that innovation is an inherently dynamic and complex process. Although Nelson himself isolates technological advance as the single most important determinant of economic growth, he also notes that the individual factors in an environment that favor innovation are not easily distinguished from one another. The use of a fixed effects panel analysis technique can control for these unobserved effects that are particular to an individual unit and/or time period. Coefficients estimated using this technique, then, may be compared statistically with coefficients generated by other means (e.g., cross-sectional regression analysis, random effects panel analysis) to determine which techniques provide more consistent estimates. In other words, the use of a dynamic technique allows our analysis to consider the unobserved criteria that Nelson predicts such analyses will encounter. The techniques also allow us to consider whether the results of the panel analysis prove statistically superior to those generated using other techniques, due to the greater control exercised.

With both these prior studies and this conceptual note in mind, we posit that an analysis of the relationships between research expenditures and revenue sources will provide insight into universities' roles in innovation, both directly indirectly. Exploring the relationship will, in turn, deepen understanding of the organizations and networks that sustain innovation, the driving force of contemporary economic development (Jessop, 1993; Nelson, 1996). Fol-

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lowing Zhang's (forthcoming) and Ehrenberg and Zhang's (2005) lead we analyze our data using both cross-sectional and panel analysis techniques in order to determine which technique proves superior. We now consider in more detail the methods by which we collected and analyzed data for this study.

Data and Methods

The main data source for our analysis is the Integrated Postsecondary Education Data System (IPEDS) administered by National Center for Educational Statistics (NCES). In this analysis, we limit our sample to Research and Doctoral institutions, for a total of 273 institutions in academic year 2007-2008: 96 Research Universities with very high research activity, 103 Research Universities with high research activity and 74 Doctoral/Research Universities (2005 Carnegie Classification System). We examine data of these institutions from academic year 1984-85 to 2007-08. The number of institutions ranges from a low of 271 to a high of 273 due to non-reporting and missing data, yielding a total of 6,543 observations over the 24-year period.

Three IPEDS components, Finance, Enrollment, and Institutional Characteristics, are used to generate the variables in this analysis. Table 1 provides information on the definition of these variables and some basic descriptive statistics for academic year 2007-08. The IPEDS Enrollment Survey provides us with information on student enrollment by level and attendance status. To standardize the data over time because definitions have changed, we compute the number of full-time equivalent (FTE) students at an institution by adding the number of full-time students and one-third of the number of part-time students. We do not differentiate among undergraduate, graduate, and first professional degree students. Using these FTE enrollments as a measure of institutional size, we construct categories of institutional revenues and expenditures on a per FTE basis. This is one of strategies that we use to control for heterogeneity across institutions and over years.

TABLE 1
DEFINITIONS AND DESCRIPTIVE STATISTICS, ACADEMIC YEAR 2007-08

	Definition	Mean	Std. Dev.
FTE	Full-time students plus 1/3 part-time students	15895	16281
Tuition	Tuition revenue divided by FTE	11214	7094
Appropriation	Federal, state, and local appropriations divided by FTE	5476	5621
Grants & Contracts	Federal, state, and local grants and contracts divided by FTE	9007	13275
Gifts	Private gifts divided by FTE	4068	8109
Sales	Sales of educational activities, auxiliary enterprises, and hospitals divided by FTE	9894	22992
Endowment & other	Endowment and other revenues divided by FTE	2619	5949
Instruction	Instruction expenditures divided by FTE	13190	12684
Research	Research expenditures divided by FTE	7062	11981
Public services	Public services expenditures divided by FTE	1357	1967
Academic support	Academic support expenditures divided by FTE	3561	4931
Student services	Student service expenditures divided by FTE	2058	2191
Institutional support	Institutional support expenditures divided by FTE	4004	4073
Scholarship	Student scholarship expenditures divided by FTE	718	799

The IPEDS Finance survey organizes institutional revenues by sources and expenditures by function. Revenue sources typically include tuition and fees; governmental (federal, state, and local) appropriations; governmental (federal, state, and local) grants and contracts; private gifts, grants, and contracts; endowment income; sales and service of educational activities, auxiliary enterprises, and hospitals; independent operations; transfers; and other sources. Expenditures include the functions of instruction, research, public service, academic support, student service, institutional support, scholarships and fellowships, and transfers. Despite changes in accounting and reporting standards (e.g., GASB and FASB) that were adopted in mid-1990s, most of these revenue and expenditure categories are quite consistent over time. There are several notable changes. For example, endowment income and transfers are no longer standard income categories in IPEDS' Finance survey; instead, investment return is reported. To accommodate this change, a new revenue category, "endowment and other incomes," is created. This category includes endowment, transfers, and other revenues in early years and investment return and other revenues in later years, so that the same revenue streams are captured over time. Revenues from independent operations usually do not support the activities accounted for by educational expenditures, and these are not considered in our analysis. All the revenue and expenditure categories in Table 1 are adjusted by student FTE to account for the differences and changes in student enrollment across institutions and over time.

Our panel data approach estimates models in which each category of institutional expenditure of institution *i* in year *t* (E_{it}) is specified to be a function of different revenue categories of institution *i* in year *t* (R_{it}). That is,

$$E_{it} = \alpha_0 + \alpha_1 R_{it} + \varepsilon_{it} \qquad (1)$$

For the pooled regression in equation (1) to produce consistent and efficient estimates, the error term ε_{it} must be orthogonal with all revenue variables, and all must be independent from each other. Unfortunately, these two conditions are not likely to hold in this situation. Because institutions are observed over time, one would assume that error terms for the same institution over time are likely to be correlated with each other, thus violating the independence assumption. For example, private institutions may rely more on tuition revenue than do public institutions and thus are more likely to devote a larger proportion of their revenues to instructional purposes. (In the analysis that follows, we conduct separate analyses for public and private institutions.) Even among public (or private) institutions, different institutions may have different priorities in resource allocation, as their institutional missions will vary. To take this unobserved institutional heterogeneity into account, we as-

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sume an error component γ_i that is unique to institution i but does not vary over time.

Similarly, there could be unobserved time specific factors that affect all institutions in the same period. This time effect is especially important in our analysis since our data span a period of 24 years. There have been year-to-year economic fluctuations that affect, for example, governmental appropriations and private gifts, which ultimately influence educational expenditures. To capture this time trend, we assume a second error component η_t that changes over time but does not vary across institutions. After building these two error components in equation (1), we have

$$E_{it} = \alpha_0 + \alpha_1 R_{it} + \gamma_i + \eta_t + u_{it} \qquad (2)$$

In our empirical analyses, we use and test different model specifications, including pooled OLS regression in equation (2), fixed effects models with only institutional fixed effects, fixed effects models with both institutional and time fixed effects as in equation (2), and random effects models. An F test is used to test the joint significance of fixed effects. Results suggest that both institutional and time fixed effects are necessary. Further, Hausman's specification test is used to test between fixed effects and random effects models. Our results favor the fixed effects models. We then estimate our preferred model (fixed effects model with both institutional and time fixed effects in this particular study) separately for public and private institutions. Results of our analyses are reported in the following section.

Results

Although the goal of this study is to identify the revenue-expenditure relationships, our focus will be on instructional and research expenditure because they are most directly related to innovation. We would like to clarify several unique aspects of our analyses before getting into the results. First, estimates produced by fixed effects models use within-institution variations over time and thus can be interpreted as changes. For example, let us assume that the estimated coefficient of grants and contacts revenues on research expenditures is 0.5. This would mean that an increase of governmental grants and contracts of one dollar at an institution would lead to a half dollar increase in research expenditures at that institution. This interpretation is different from the cross-section setting, where the same coefficient would be interpreted to mean that institutions with more grants and contracts are spending more on research, which, while true, might be caused by other, confounding factors.

Second, revenues and expenditures in actual dollar amount are reported. Typical production functions, such as Cobb-Douglas, require the logarithm transformation, and thus regression results can be interpreted as elasticities. We use both the actual dollar amount and its natural logarithm form in our analyses but ultimately report the results in actual dollar terms. Typical production functions assume decreasing marginal productivity. That is, as an increase of one input occurs, the resulting marginal productivity/utility decreases. Although it is possible that due to restrictions imposed by revenue providers (e.g., private donors may designate the use of their donations) some restricted revenue sources may exhibit decreasing marginal utility, institutions can reallocate unrestricted funds across different functional areas. We feel it is safe, in this particular case, to use the actual dollar form instead of making the logarithmic transformation.

Third, because our analysis uses approximately 270 institutions over a 24-year period, it is not surprising that many estimated coefficients turn out to be statistically significant; economic significance is more important than statistical significance in this study. For example, a 3-cent increase in research expenditure resulting from a one dollar increase in total sales and services could be statistically significant but would be considered to be economically insignificant.

Table 2 reports the fixed effects estimates in dollar terms for the effect of changing revenue sources on expenditure categories at *public* institutions. Our dependent variables in the head row include (1) instruction, (2) research, (3) public service, (4) academic support, (5) student services), (6) institutional support, and (7) scholarship and fellowships. Independent variables include (1) tuition and fees, (2) appropriations, (3) grants and contracts, (4) gifts, (5) sales and services, and (6) endowment and other revenues.

Each coefficient in the table can be interpreted as the change in the expenditure of the corresponding column caused by one dollar change in the revenue of the corresponding row. For example, the coefficient 0.091 in the fourth row and fourth column suggests that a one dollar increase in private gifts per FTE leads to 0.091 dollar increase in academic support expenditures.

TABLE 2
ESTIMATES OF INSTITUTIONAL REVENUES ON EXPENDITURES AT PUBLIC RESEARCH/DOCTORAL INSTITUTIONS (PER FTE IN $)

	(1) Instruction	(2) Research	(3) Public Services	(4) Academic Support	(5) Student Services	(6) Institutional Support	(7) Scholarships
Tuition	0.429^{***}	0.097^{***}	-0.079^{***}	0.099^{***}	0.081^{***}	0.104^{***}	0.146^{***}
	(0.033)	(0.012)	(0.011)	(0.007)	(0.004)	(0.007)	(0.008)
Appropriations	0.323^{***}	0.104^{***}	0.061^{***}	0.085^{***}	0.041^{***}	0.116^{***}	0.025^{***}
	(0.018)	(0.006)	(0.006)	(0.004)	(0.002)	(0.004)	(0.005)
Grants & Contracts	0.278^{***}	0.447^{***}	0.066^{***}	0.076^{***}	0.015^{***}	0.027^{***}	0.030^{***}
	(0.019)	(0.007)	(0.006)	(0.004)	(0.002)	(0.004)	(0.005)
Gifts	0.175^{***}	0.317^{***}	0.137^{***}	0.091^{***}	0.023^{***}	0.067^{***}	0.021^{*}
	(0.040)	(0.015)	(0.013)	(0.009)	(0.005)	(0.009)	(0.010)
Sales	0.027^{**}	0.028^{***}	0.041^{***}	-0.003	-0.004^{***}	0.005^{*}	-0.006^{*}
	(0.010)	(0.004)	(0.003)	(0.002)	(0.001)	(0.002)	(0.002)
Endowment & other	0.012	0.069^{***}	0.147^{***}	0.017^{***}	-0.005	0.006	0.012^{*}
	(0.023)	(0.008)	(0.008)	(0.005)	(0.003)	(0.005)	(0.006)
Observations	3982	3982	3982	3982	3982	3982	3982
R^2	0.300	0.771	0.302	0.458	0.442	0.394	0.474

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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The first column (instruction) of Table 2 suggests that revenues from tuition, appropriations, and grants and contracts contribute importantly to instructional expenditure. To be more specific, a one-dollar increase in tuition, appropriation, and grants and contracts increases instructional expenditures by 0.429, 0.323, and 0.278 dollars, respectively. Gifts have a moderate effect on instructional expenditures at 0.175 whereas the remaining two income sources, namely sales and services and endowment and other revenues, have almost negligible effects on instructional expenditure.

The second column reports the results for research expenditures. Besides governmental grants and contracts, which have largest impact on research expenditures at 0.447, private gifts, grants, and contracts also have a large effect on research expenditures. On average, a one-dollar increase in private gifts, grants and contracts increases research expenditures by 0.317 dollar. Tuition and appropriations have rather moderate effects on research expenditures. On average, a one-dollar increase in these two revenue sources only increases research expenditures by about 10 cents each. The other remaining categories, sales & services and endowment & others, have minimal impacts on research expenditures.

Results pertaining to the remaining 5 expenditure categories are briefly summarized as follows. Whereas public services expenditures are moderately predicted by private gifts and endowment revenues, interestingly, tuition revenues have a negative impact on public services expenditures, suggesting that as public institutions become more tuition driven, they downplay public service. Academic support expenditures (e.g., libraries, instructional media) are moderately predicted by revenues from tuition, appropriations, governmental grants and contract, and private gifts, with estimated effects all less than 0.1. Not surprisingly, student services expenditures are at least moderately predicted by tuition revenues, but are influenced by other revenues only minimally. Institutional support (general administration) expenditures are mainly from tuition and appropriation revenues. Finally, student scholarships and fellowships are moderately predicted by tuition revenues.

Table 2 can also be read from the other direction. That is, instead of looking at how each category of expenditure is affected by different revenue sources, one might be interested in knowing how each category of revenue is expended. For example, for each dollar increase in tuition, public institutions spend almost 43 cents on instruction, 15 cents on scholarship and fellowships, and about 10 cents on research, academic support, student service, and institutional support, respectively. It is noteworthy that these numbers do not add up to one dollar. The reason is that some expenditure categories, such as operation and maintenance and non-educational expenditures, are excluded from our analysis. About one-third of government appropriations are used for instruction, with the rest spread among other functional areas. Government grants and contracts are mainly used for research (45 cents out of one dollar) and instruction (28 cents out of one dollar) purposes, with the rest spread among other functional areas. Private gifts, grants, and contracts are also used mainly for educational purposes, with the largest share (32 cents out of each dollar) going to research. The remaining two categories of revenues mainly are not for educational purposes. Revenues from sales and services are generally used to cover the expenses of producing these sales and services, including for example hospitals and auxiliary enterprises.

Results for private institutions are reported in Table 3. Although the general pattern we observe from the public institutions in Table 2 applies here, there are several notable differences. It is noteworthy that private institutions in general receive little or no government appropriations, so this revenue category is omitted from our analysis. The first noticeable difference between private and public institutions is that the former devote a relatively small proportion of tuition revenues (about 16 cents out of one dollar) to instructional purposes. However this does not necessarily mean that those who pay high tuitions to attend private institutions get “ripped off”; in fact, the contrary may be true. Because faculty salaries compose the largest subcategory of instructional expenditures, a small coefficient here simply indicates a relatively weak association between tuition levels and faculty salaries at private institutions. Other factors must explain the relatively high salaries in private institutions. This finding is consistent with previous studies that have shown that faculty salaries are not the main factor for rapidly rising tuitions at private institutions (Ehrenberg 2004). In addition, tuition revenues do not seem to affect research expenditures at private institutions, suggesting that tuition revenues are not used for research purposes at private institutions. Finally, for each additional tuition dollar, private institutions devote about 43 cents to institutional support of which library spending is the largest subcategory. These results suggest that private institutions devote much of their tuition revenues to areas that benefit their students disproportionately.

TABLE 3
ESTIMATES OF INSTITUTIONAL REVENUES ON EXPENDITURES AT PRIVATE RESEARCH/DOCTORAL INSTITUTIONS (PER FTE IN $)

	(1) Instruction	(2) Research	(3) Public Services	(4) Academic Support	(5) Student Services	(6) Institutional Support	(7) Scholarships
Tuition	0.159^{***}	-0.003	0.002	0.094^{***}	0.109^{***}	0.432^{***}	0.074^{***}
	(0.007)	(0.004)	(0.003)	(0.006)	(0.002)	(0.004)	(0.003)
Grants & Contracts	0.466^{***}	0.794^{***}	0.013^{*}	0.119^{***}	0.035^{***}	0.176^{***}	-0.014^{*}
	(0.016)	(0.009)	(0.006)	(0.013)	(0.005)	(0.010)	(0.006)
Gifts	0.192^{***}	0.126^{***}	0.010	0.075^{***}	0.051^{***}	0.131^{***}	-0.049^{***}
	(0.015)	(0.008)	(0.006)	(0.012)	(0.005)	(0.009)	(0.006)
Sales	0.033^{***}	0.022^{***}	-0.006^{*}	0.044^{***}	0.001	-0.006	0.001
	(0.006)	(0.003)	(0.002)	(0.005)	(0.002)	(0.004)	(0.002)
Endowment & other	-0.008	0.028^{***}	0.001	-0.019^{***}	-0.003	-0.008^{**}	-0.002
	(0.004)	(0.002)	(0.002)	(0.004)	(0.001)	(0.003)	(0.002)
Observations	2558	2558	2558	2558	2558	2558	2558
R^2	0.656	0.882	0.013	0.322	0.583	0.846	0.710

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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Government grants and contracts contribute to instructional expenditures significantly. For each additional dollar of grants and contracts, instructional expenditures increase by about 47 cents. The difference in the relationship between tuition revenues and instructional expenditures and between government grants and contracts and instructional expenditures probably reflects different faculty reward mechanisms at public and private institutions. It is plausible that at private institutions faculty are more likely to be rewarded for their research productivity, so that increased grants and contracts are tightly related to higher faculty salaries, which are in turn reflected in larger instructional expenditures because that is where these salaries are assigned under accounting standards. The relationship between grants and contracts revenues and research expenditures is much tighter at private institutions than at public institutions. At private institutions, for each additional dollar of government grants and contracts, there is an increase of almost 80 cents increase in research expenditures. Finally grants and contracts also have moderate effects on academic and institutional support expenditures. One interesting finding is that for each additional dollar of government grants and contracts, the total impact on educational expenditures is more than one dollar. This is consistent with the recent literature in this area, suggesting that institutions increasingly are using their own resources to fund research (Ehrenberg, Rizzo, & Jakubson 2007; Zhang & Ehrenberg forthcoming).

Private gifts, grants, and contracts have moderate effects on instruction, research, and institutional support. Each additional dollar of private gifts increases expenditures in these three areas by 19 cents, 13 cents, and 13 cents, respectively. Finally, similar to public institutions (Table 2), revenues from sales and services and from endowment and other sources do not seem to contribute to educational expenditures in an economically significant way.

Conclusions and Discussion

In this study, we examine the revenue-expenditure relationships for public and private research and doctoral universities. Results suggest tight relationships between some revenue and expenditure categories. Both statistically and economically, instructional expenditures are found to be influenced significantly by revenues from tuition and fees, governmental appropriations (for public institutions), and grants and contracts. Research expenditures are affected first and foremost by government grants and contracts, especially at private institutions. Revenues from tuition, appropriation, and private gifts have a rather moderate effect on research expenditures. Student service, institutional support, and scholarships and fellowships are significantly related to revenues from tuition and fees.

Given these results, the changing financing patterns in U.S. higher education, especially at public institutions, during last three decades or so has had a direct impact on the priorities of higher education institutions. For example, decreased state appropriations have meant decreased instruction and public service expenditures, in relative terms. While the relatively reduced state appropriations may have been compensated for by increased tuition revenues, the public service function of public institutions certainly has diminished. On the other hand, increased revenues from grants and contracts for both public and private institutions imply that institutions are now engaging in research activities more aggressively than before. This increase, of course, speaks to the increasing importance of universities in regard to innovation, nationally.

If research is understood as the central component of innovation, then the policy implications may be to leave well enough alone. Federal R&D research revenues for universities have increased every year since 1982, with one or two exceptions and currently stimulus funds are expanding federal R&D funds (Greenberg 2001, NSF 2009). However, federal R&D funds for research universities have declined relative to other research support, particularly in relation to the funds universities provide from their own resources (NSF 2009). This raises questions about the revenue sources of these funds, now approximately 20% of research expenditures at research universities.

Generally, the IPEDs expenditure categories do not help us address these questions. IPEDs expenditure categories are very broad and do not necessarily reflect activities by university personnel in a fine grained way. For example, all faculty salaries are counted as instructional expenditures: "Instruction – A functional expense category that includes expenses at colleges, schools, departments, and other instructional divisions of the institution and expenses for departmental research and public service that are not separately budged (IPEDS)" . Yet we know that faculty at the 100 research universities receiving the largest amounts of public and private grants and contracts for research very likely spend a substantial amount of their time on research. Research as a functional expenditure category is defined more precisely: "expenses for activities specifically organized to produce research outcomes and commissioned by an agency either external to the institution or separately budgeted by an organizational unit within the institution…include [ing] institutes and research centers, and individual and project research (IPEDS)." The operative definition of research seems to be externally funded and/or "separately budgeted." Presumably, the normal load of a faculty member at a research university, (conventionally understood as 40% research, 40% teaching, 20% service) is captured as "departmental research" under the instructional category, while only sponsored or separately budgeted research is captured in the research category. Centers and institutes introduce more complexity, since some are separately budgeted and others are not, and frequently faculty have simultaneous appointments in departments, centers and institutions. Overall, accounting conventions probably underestimate university expenditures on research...

The lack of fine-grained categories means that we are unable to look in a nuanced way at how research universities spend their revenues to contribute to the "co evolution" of research, technology, patents, know-how, and firms. It is possible that more refined expenditure categories would allow us to surmise intra-organizational structures that affect

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whether a research university participates in innovation. While we analyzed the IPEDS data using panel techniques that can account for the unobserved effects of specific units and/or time periods, the very broad functional expenditure categories may cause us to miss the intra-organizational structures that would contribute to our understanding of innovation. For example, universities may have developed unobserved effects stemming from reconcentration of instructional expenditures on research that contribute to innovation. Since these funds may be used in a discretionary way, they could be rapidly deployed as to target research likely to create technology that could contribute quickly to innovation. Rather than "ripping off" students by spending funds on research, universities may be expending revenues in new and creative ways to contribute to technology that leads to innovation and economic growth. In other words, universities' expenditure strategies may be building a growth economy critical to creating high skill, high salary jobs for their graduates.

While our study explicates the revenue-expenditure relationship, future studies will focus on more tangible outcomes. We will examine degree production in relations to revenue and expenditure patterns in much greater detail, as referenced in the introduction. For example, how does degree production vary across fields that are important to innovation, as revenue and expenditure patterns are varied? And to what degree does research production, as measured for example by publications, patents, licenses, and startups vary with revenue and expenditure variations over time? What role do centers and institutes play in this mix? Do results change if we consider only the top 100 recipients of public and private research grants and contracts?

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